DOCUMENT RESUME

ED 150 200 TM 006 942

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TITLE Simulation Evaluation Designs.
PUB DATE Apr 77
NOTE 19p.; Paper presented at the Annual Meeting of the American Educational Research Association (61st, New York, New York, April 4-8, 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Academic Achievement; Classroom Environment; *Classroom Research; College Students; Effective Teaching; *Evaluation Methods; Higher Education; Individualized Instruction; Motivation; *Research Design; Research Problems; *Research Reviews (Publications); *Simulation; *Teaching Methods; Validity

ABSTRACT

The failure to find strong instructional effects of simulation is usually attributed to poor measurement and faulty research design. However, weak implementation of simulation into the classroom, rather than methodological inadequacy, is presented here as the primary reason for finding insignificant effects. The types of environments under which simulation would be expected to have its greatest impact have rarely been arranged, and thus the claims made for simulation have not been adequately tested. It is proposed that future studies should be directed toward using simulation as a vehicle for creating distinctive learning environments. Some suggestions for accomplishing this goal include: (1) establishing the phenomenological validity of the simulation, (2) creating a distinctive learning environment--using the simulation to integrate the course content, to reinforce ongoing learning, or as an advance organizer, (3) establishing the motivational context, and (4) validating simulation as an instructional process. (Author/MV)

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SIMULATION EVALUATION DESIGNS

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Paper delivered at the Annual Meeting of the American Educational Research Association, New York City, April 4-8, 1977

Simulation Evaluation Designs

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Abstract

The failure to find strong instructional effects of simulation is usually attributed to poor measurement and faulty research design. It is argued here that weak implementation of simulation into the classroom rather than methodological inadequacy is the primary reason for finding insignificant effects. The kinds of environments under which simulation would be expected to have its greatest impact have rarely been arranged, and thus the claims made for simulation have not been adequately tested. It is proposed that future studies should be directed toward using simulation as a vehicle for creating distinctive learning environments. Some suggestions for accomplishing this goal are offered.

Evaluating Simulation Designs

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Before commenting specifically on the virtues of simulation (broadly speaking) as an instructional mode, I would like to briefly review what the research literature tells us about the differential effects of teaching formats at the college level. After reviewing that literature during the past year, I can't help but take a rather pessimistic view of claims for the superiority of one method over another. Empirical support for these claims simply isn't there.

With the exception of the so-called behavioral technologies, which have proven to be highly effective in enhancing student learning and retention, there is absolutely no convincing evidence that anything less than a dramatic change in how we teach is going to differentially affect student performance. This fact is most convincingly made by Dubin and Taveggia (1968) who, after reviewing almost 100 studies of college teaching methods, reached the following conclusion:

> These data demonstrate clearly and unequivocally that there is no measurable difference among truly distinctive methods of college instruction when evaluated by student performance on final examinations (p. 35).

The "truly distinctive" methods referred to in this statement were lecture, discussion, lecture-discussion, and independent study--both supervised and unsupervised.

As mentioned above, the one exception to this conclusion are the behavioral technologies, most notably Keller's (1968) Personalized System of Instruction (PSI)

which has been found to consistently facilitate learning compared to conventional modes of instruction (Kulik & Jaksa, 1977; Robin, 1976; Taveggia, 1976). This is indeed a rare occurrence in the annals of educational research.

I mention PSI here because it, like simulation, deserves the label of a "truly distinctive" method of teaching. Unlike almost all of the methods looked at by Dubin and Taveggia, which are actually quite similar in many important respects (e.g., students spend considerable time reading and studying a text in each--most likely in the same manner), PSI fundamentally changes the learning environment and literally forces students to alter their behavior. Tests become frequent, feedback on performance is immediate, and mastery of the material is demanded. And these features of PSI are the apparent causes of the improved performance. But the point I wish to emphasize is that, in light of what we have learned about teaching methods, it will take changes in the learning environment on the order of those produced by PSI before a new approach should even be considered as a potential candidate for effecting significant change in student performance.

Now let's consider whether simulation qualifies as a "truly distinctive" method or if it is best thought of as a variation of conventional modes of instruction. In its pure form, at least, the answer has to be in the affirmative. Students become (are encouraged to be) active rather than passive, and the mode of learning shifts from information-processing to experiental. Without going into greater detail, since most of us are already familiar with the nature of simulation activities, it seems safe to conclude that the simulation environment is fundamentally different from those created by conventional teaching methods. Hence we have a reason for being optimistic about the educational virtues of

simulation. We can now take a look at what the research literature tells us about its effectiveness.

The Evidence

When asked to explore the literature on the educational effects of simulation, an area with which I was only partially familiar, I began with the hope that I could perform what Gene Glass (1976) in last year's presidential address at AERA called a "meta-analysis" (an analysis of analyses) on simulation research. Much as he went about assessing the effectiveness of psychotherapy, I intended to collect all of the research studies available, describe the "effect size" for each measure in standard deviation units, and then make a number of comparisons as a function of a host of simulation variables--for example, type of simulation, its duration, age of participants, extent of role playing, etc. The rationale seemed simple enough and I was initially optimistic enough to believe that I could make as much sense out of the simulation literature as Glass and his colleagues did out of the almost 400 studies of psychotherapy they analyzed. That I failed to do so, or even bother to perform the analysis hoped for, serves as the basis for much of what I will subsequently say about simulation evaluation designs. It became clear rather quickly that, with the exception of showing that simulation is better than nothing (i.e., no treatment control groups), my analysis would reveal no significant effects of simulation compared to conventional teaching methods. As an agnostic with regard to the virtues of simulation, the absence of a strong impact did not disturb me personally. But as a methodologist, I could not convince myself that simulation had really been given a chance. Poor research designs or implementation strategies seemed to be equally likely explanations of the lack of strong effects and thus I came to the conclusion that the

kind of summative evaluation I had in mind was premature. There was, moreover, the tremendous enthusiasm for simulation by people for whom I had a great deal of respect that dissuaded me from putting too much faith in the literature. I therefore decided to focus my attention upon future directions for simulation research rather than commenting on the apparent inadequacy of the research up to this point in time.

Before moving on to specific recommendations, I should mention that my conclusions about the literature on simulation are shared even by the strongest advocates of simulation techniques, conclusions which, incidentally, have not changed significantly after a decade of research. For example, Livingston and Stoll (1973), after reviewing the literature, suggest that the choice of simulation as an instructional tool must be based upon the advice of colleagues or personal experience, a position that reminds one of the "acceptance on faith" phase of simulation history described by Boocock and Shild (1968). Implicit agreement with this conclusion is indicated by a call for more research by all the reviews I consulted. My own concern, however, is whether more of the same kind of research will substantively modify this conclusion in the future. Perhaps a new approach must be taken if the educational benefits of simulation are to be fully realized.

Interpreting the Evidence

How are we to interpret the generally negative or, at best, weak effects produced by simulation? Of course, one obvious explanation is that simulation simply isn't as powerful as we once believed. This may or may not be the case but, as mentioned above, such a conclusion is premature. Moreover, it doesn't explain the occasional finding of strong positive effects. A second possibility,

one which is often cited, is that the effects are there but our measuring instruments are too insensitive to detect them. Related to this view is a third alternative which suggests inadequate methodology as the culprit--that is, the "noise" created by sloppy designs masks the effects produced by the simulation exercise. Although there is definite room for improvement in the methodological aspects of simulation research (more appropriate controls, better measurement, etc.), there may be a fourth explanation which is even more important. Specifically, it will be argued here that, aside from methodological difficulties, the real problem is that most of the research on simulation has been biased against finding significant effects. In other words, it is not the research which is at fault, but the way in which simulation has been implemented into the classroom. If this is the case, as I will attempt to document below, some of the most ardent supporters of simulation find themselves in the ironic position of undermining faith in the instructional method the effectiveness of which they had hoped to demonstrate. I turn now to a more detailed treatment of this issue.

The neutral observer is bound to be struck by the obvious discrepancy between the stated expectations for a given simulation exercise and its actual incorporation into the classroom. Put simply, what appeared to be "truly distinctive" at a theoretical level becomes commonplace in practice. Consider, for example, a slightly exaggerated but not too atypical setting for the simulation exercises described in the research studies. The first thing one notices is that the exercise seems to be only tangential to the main purpose of the classroom. Secondly, participation is rarely made contingent upon prior preparation by the students. A brief description is offered, materials (if any) distributed, and the exercise begins. And soon thereafter it is over, usually

lasting for a brief period of time. Another feature of many simulations is that successful completion of the exercise does not require the learning of anything new. In fact, one usually has no way of knowing the level of participation by a given student. Moreover, the simulation activities are generally independent of the ongoing motivational structure of the class. A final characteristic is that the activities engaged in during the simulation are typically not reinforced by subsequent events taking place in the classroom. Put in its simplest terms, the simulation often bears only a superficial relationship to the overall structure of the course, may be in direct conflict with other motivational constraints imposed in the course (as well as those in courses taken concurrently), and usually involves no provisions for the subsequent strengthening of the processes activated during the exercise. Given these conditions, an outsider like myself wonders not why measurable effects of simulation have been hard to come by, but why anyone should expect anything more than a transitory effect in the first place! Quite frankly, I have the impression that an appropriate analogy for many simulations is the "school recess," a brief time out from more serious pursuits, enjoyable to be sure, but hardly expected to significantly modify the cognitive and affective structure of the individual. Interestingly, the one reasonably consistent effect of simulation, what Goodman (1973) has called the "consummatory side" of simulation activities, fits in nicely with the analogy. But this is not the way to assess the relative merits of what many believe to be a serious challenger to traditional educational practices.

Recommendations for the Future

If we have learned anything from the past fifty years of research on college teaching, it is that tinkering with the instructional process within a conventional

framework will not differentially affect student performance. The research data cited earlier by Dubin and Taveggia (1968) make this point quite clear. I submit that simulation all too often falls within the tinkering category and thus should not be expected to produce striking effects as it is currently implemented into the classroom. It has been robbed of its "truly distinctive" nature (perhaps by institutional restraints), the consequence being very weak tests of its effectiveness. A fairer test of the potential benefits to be derived from simulation demands much more, the issue to which I now turn. The suggestions offered should be taken as working hypotheses with little and sometimes no empirical support. However, several of the ideas presented have been derived from simulation exercises from which positive effects have been found. My tactic was to use these cases as the basis for developing some hypotheses about the components necessary for a successful simulation exercise.

1. Establish the "Phenomenological Validity" of the Simulation. The ideal simulation, I think, would take place in an environment in which administrators, colleagues, and students view simulation activities as legitimate learning experiences. This is what Bronfenbrenner (1976) class the "phenomenological validity" of the exercise (and experiment). A requirement of this kind is probably difficult to satisfy in many instances, but it is absolutely essential in the case of simulation because of the "gamelike" nature of many exercises. Of course, the manner in which the simulation is actually incorporated into the classroom will determine to a large extent how participants perceive the exercise (as indicated below), but the broader context can also play a significant role. In either event, care must be taken to establish the validity of the exercise and a measure of phenomenological validity should become part of future research.

2. Create a Distinctive Learning Environment. Although relevant details are often missing in the research reports, one gets the impression that in many experiments the dominant mode of instruction is actually quite conventional with the exception of the typically brief simulation exercise. In my mind, this is an extreme form of the tinkering mentioned earlier and should not be expected to have much impact. (One might also wonder about the phenomenological validity of such experiments.) A strong test of simulation's effectiveness would establish the simulation as the focal point in a course, around which all other activities are built. If positive effects are found in this case, we could then consider how much our new environment could be degraded and still produce the desired effects. But we should start with strong tests of our hypothesis.

Of course, the exclusive use of simulation in the classroom may neither be possible or desirable. Nonetheless, the important criteria for a fair test are (1) that we establish the simulation as one of the dominant modes of learning in the course, and (2) incorporate the simulation into the total context of the course. There are a number of ways in which this might be accomplished, a few of which will now be mentioned. However, the important point is that we begin to think of simulation within the overall course structure rather than as a brief time out from business as usual.

a. Simulation as a Course Integrator. One could make a good argument, I think, for viewing many simulations in terms of a culminating learning experience within a course. In fact, we might even create a situation in which all prior course activities are conceived as preludes to the final act of the course--the "putting it all together" in the simulation exercise. This would be a particularly strong test of the effectiveness of simulation since it makes the exercise the

most important component in the course, all other activities being subordinate, and hence the learning environment takes on a completely different character. If simulation is indeed an important mode of instruction, I would expect strong effects to emerge under these circumstances.

I recently had the opportunity to observe a simulation conceptualized as a course integrator at the University of Michigan. The simulation, called the Middle East Conflict Simulation Game and developed by Len Suransky, was carefully embedded into a course on the Israeli-Arab conflict. Much of the students' work during the semester was geared toward ultimate participation in the game, which consisted of assuming the role of a given personage and becoming involved in negotiations for a settlement. Although not subjected to an experimental evaluation, a videotape provided by Suransky suggests powerful effects of the game. The motivational consequences, both before and after the play of the game, were most obvious. Some hints that the game also served an integrative function were available, especially for the principles involved in the negotiations, but any strong conclusions must await a more rigorous analysis. Nonetheless, the model provided by Suransky's monumental effort is one which should be emulated in future simulation research. It is a striking example of creating a fundamentally different and integrated learning environment through simulation.

b. Simulation as a Reinforcer of Ongoing Learning. A second way to conceptualize simulation exercises is to think of them much as we do laboratory experiences--concrete "hands-on" activities which are meant to both strengthen and extend learning via more conventional modes. Depending upon the extent to which the exercises are tied in with other components of the course and viewed as the focal point for each segment of the course, this approach could establish

a relatively distinctive learning environment. Conceptually, we can think of each exercise as a mini-integrator for the material covered prior to participation in the simulation.

One of my colleagues at Denison University, Paul King (1976), an economist, has recently completed an analysis which demonstrates a successful application of an approach consistent with this notion. Students in a macroeconomics class spent considerable time working with computer simulations of the aggregate economy in addition to studying a text and attending lecture-discussions. Compared to an equivalent control class that was treated essentially the same with the exception of the simulation exercises (but added reading materials), the students were found to perform significantly better on a set of questions requiring the application of macroeconomic principles. Presumedly, the opportunity to engage in the simulation exercises allowed the students to sharpen their problem-solving skills. Whatever the case, note that care was taken to incorporate the exercises within the total context of the course, both establishing their phenomenological validity and building upon prior learning as was also the case in the Suransky simulation of the middle east conflict.

c. Simulation as an Advance Organizer. A third potential way to conceptualize simulation exercises, especially certain games, is as advance organizers for subsequent learning. Ausubel (1963) has argued that advance organizers can facilitate learning by providing a general overview of material prior to a more detailed consideration and serve an organizational function. Research on the ability of advance organizers to enhance learning has been mixed (Barnes & Clawson, 1975), but the role of simulation in serving this purpose has not been fully investigated. Ideally, each segment of the course would be preceded by a

rather extensive simulation exercise, which would then serve as a focal point for subsequent reading and classroom activities. This approach does not represent a strong departure from a conventional mode of instruction, but it may be worth trying. It satisfies our criterion for becoming integrated into the overall structure of the course and, with some modifications and imaginative teaching, could lead to the creation of an environment in which the simulation exercises play a dominant role.

3. Establish a Motivational Context. Incorporation of simulation activities into the overall course structure necessarily includes motivational variables. However, perhaps because of the presumed "autotelic" (self-directed) nature of simulation exercises, it is indeed a rare occurrence when performance in a simulation is part of the classroom reward structure. Students simply aren't held accountable for their level of performance on the exercise, the net effect of which is likely to be something less than total involvement by many students and some questioning of the legitimacy of the exercise as a learning experience. Some will no doubt recoil at the thought of imposing motivational constraints on what seems to be an inherently interesting activity, but we must keep in mind other demands which are placed upon students. They must be pragmatic in how they invest their time and energies, and this usually means devoting oneself to those activities most closely related to course success (i.e., grades).

Some obvious ways to establish a motivational context for simulation are to differentially reward level of performance in the exercise, develop tests more directly linked to the simulation activities, or, even better, make completion of a successful exercise contingent upon the acquisition of certain cognitive skills which in turn serve as a basis for evaluation in the course. This was an inherent

feature of the computer simulations used by King (1976) and (I assume) in Suransky's simulation of the middle east conflict. An even clearer example is provided by DeVries (1976) in his research on the so-called "Teams-Games-Tournament" technique. Although relevant primarily to nonsimulation exercises (which, incidentally, were found to be highly effective), DeVries has suggested a learning and motivational structure which may have implications for the design, play, and evaluation of simulation activities. The essential feature of his approach involves the simultaneous use of both the information-processing and experiential modes, along with a supporting motivational context. This is basically what is here being suggested as a model for a fairer test of what simulation can and cannot do in the classroom.

4. Validate the Simulation Process. Efforts to embody simulation within a total learning and motivational environment will unquestionably lead to a better understanding of simulation as an instructional tool, but none of the suggestions offered thus far really carry us beyond a somewhat superficial analysis. Eventually, we must come to understand the cognitive and affective processes activated during a given simulation exercise. For too long we have assumed that these processes are an automatic effect of simulation exercises and that they are roughly identical from one simulation to the next.

Consider, for example, that in the King study cited earlier the computer simulations facilitated performance on simple application questions but not on those of a more complex nature. Why was this the case? More generally, why are some simulations more successful than others? When we can answer this question, we have understood the processes which must be activated in order to produce a particular learning outcome.

Getting back to the King study, he has made the not unreasonable argument that the complex questions on his examination were more sophisticated than any of the simulation models utilized by his students. This is an interesting point since it suggests a direct link between the cognitive processes evoked during the exercises and subsequent performance. In other words, he is implying a rationale for predicting the conditions under which a simulation will or will not be effective: If these processes are activated (and presumedly practiced), they will be enhanced; if not they will remain unchanged. This is, of course, nothing more than a version of the view that learning requires active and constructive processes. But the presence of these processes has too often been taken for granted in simulation exercises when, in fact, they may not exist, or at least vary considerably in degree across simulations. Clearly, an analysis of simulation at this level must be considered the ultimate goal of our research efforts since it should lead eventually to causal statements about the processes activated during simulation and instructional effects. Note also that it will provide a rational basis for constructing measurement instruments, thus eliminating the "shotgun" approaches that have guided most research efforts. The obvious first step in achieving this goal is much greater precision in describing what students do during a simulation exercise. A similar (but more fully developed) point has recently been made by Esther Thorson (1977), Director of the Denison Simulation Project, who, in addition to making a cogent argument for conceptualizing simulation as a rather pure form of problem-solving activity, has questioned the degree to which many simulations meet the criteria for inclusion into this category.

Conclusion

In response to allegations that compensatory education was a failure, many critics claimed that it hadn't really been tried. My own analysis of the literature suggests that a similar conclusion is appropriate for the research on the educational effectiveness of simulation. We haven't really arranged the kinds of environments under which simulation would be expected to have its greatest impact, and thus we don't know if the claims made for simulation are valid. And while the call for better research designs and measurement should be needed, it is doubtful whether more studies along the lines of those already conducted will provide the answers we need. Incorporation of simulation into the total learning environment and the identification of the cognitive and affective processes activated by simulation exercises are viewed as the key elements of an adequate research program.

Implicit in the foregoing comments is the belief that the research literature provides a reasonably accurate picture of the effects of simulation as it is currently utilized in many classrooms. Past research tells us that significant changes in student behavior do not come easily, and a brief simulation exercise within the conventional mode simply is not a major restructuring of the learning environment. Significant changes should not be expected and, consistent with this argument, they have rarely been found. We must, therefore, redirect our efforts to create fundamentally different learning environments via simulation activities. Only then will we discover if simulation is indeed an effective technique for achieving our educational goals.

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